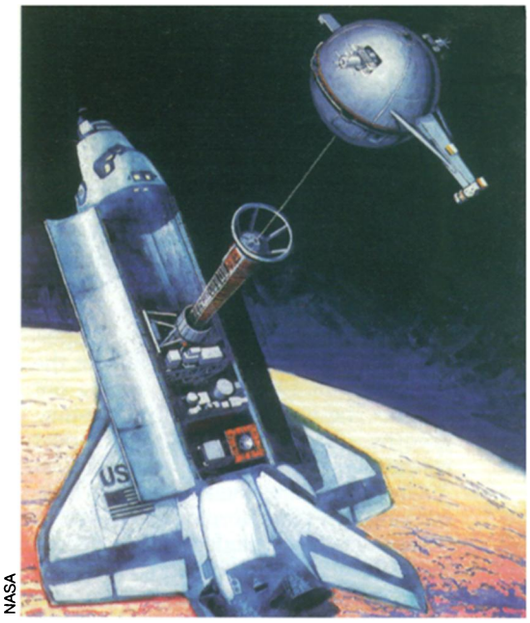
New Year in Space Science

Explorations for '96

By RON COWEN



NASA

A line to the universe: the Tethered Satellite System deployed from the payload bay of the space shuttle.

From three new journeys to Mars to a satellite hanging by a rope in space, the New Year offers a wide variety of space science missions—several of them spearheaded by space agencies from Italy, Russia, Argentina, Germany, and Japan. If a series of planned launches stays on schedule, 1996 should see the assembly of an armada of craft devoted to studying the sun and its influence on Earth. These missions, which together form the International Solar-Terrestrial Physics program, have suffered long delays because of continuing problems with two launch vehicles—the Pegasus rocket in the United States and the Ariane-5 rocket in Europe.

In contrast to the flurry of activity centering on our solar neighborhood, NASA this year plans fewer missions to observe the more distant reaches of our galaxy. In part, says NASA scientist Edward J. Weiler, that's because the agency is developing new space-based strategies to search for planets orbiting nearby stars.

These plans face the harsh reality of massive budget cuts. Beginning this year, reduced spending is forcing NASA to launch only seven shuttle missions a year rather than eight.

January

● Last year, the Infrared Telescope in Space, a U.S.-Japanese mission to study infrared emissions from our galaxy, soared aloft on an expendable Japanese rocket. By the end of this month, the robotic arm of a space shuttle is expected to snare the satellite for a return trip to Earth.

● On Jan. 22, NASA expects to kick off the year's launch schedule by putting the Polar spacecraft into Earth orbit. Designed to record the energetic particles, magnetic and electric fields, and dazzling auroras over Earth's magnetic poles, Polar carries a suite of 11 instruments. Venturing as close to Earth's surface as 1.8 Earth radii (12,700 kilometers) and never straying farther than five times that distance, the craft will image auroral fireworks with X-ray, ultraviolet, and visible-light cameras.

Polar complements a mission scheduled for launch in July to examine finer-scale structure in the aurora. Researchers also plan to coordinate Polar observations with those taken by the recently launched Wind craft, which tracks the wind of charged particles streaming out from the sun in the region where it first encounters Earth's magnetic field.

February

● Thought to be relics from the era of planet formation 4.5 billion years ago, asteroids hold clues to the nature of the early solar system and the processes that built Earth and the other inner planets. Near-Earth asteroids in particular intrigue astronomers because they sometimes collide with Earth, greatly influencing—sometimes catastrophically—the evolution of the atmosphere and life on our planet.

In February, NASA plans to launch the first craft designed to orbit an asteroid. The Near Earth Asteroid Rendezvous (NEAR) mission also represents the first in a series of low-cost craft known as the Discovery program. NEAR's first planned journey takes it through the asteroid belt, the vast ring of rocky debris that lies between Mars and Jupiter, passing by the main-belt asteroid 253 Mathilde in June 1997. After swinging back around Earth for a gravity assist in early 1998, NEAR should meet the near-Earth asteroid 433 Eros a year later and orbit the rocky body for 11 months. Ultimately orbiting Eros at a distance of just 100 km, the craft is expected to make some of the first close-up measurements of an asteroid, reporting its surface composition, size, shape, volume, and mass.

Such detailed study may help test a widely held hypothesis that most meteorites striking Earth are fragments of the most common type of asteroid.

● The Italian Space Agency plans to launch an ambitious X-ray observatory, Satellite per Astronomia X (SAX). Designed to last for at least 2 years, SAX will be the first mission to observe X-ray sources over a broad band of energies, ranging from 100 to 300,000 electronvolts. Other X-ray observatories, including the German craft ROSAT and the Japanese satellite ASCA, survey the X-ray sky over a much more limited energy range.

Several telescopes on SAX will take images and spectra over narrow regions of sky. In addition, two wide-field cameras will scan large sections of the sky in an attempt both to monitor the long-term variability of known sources of X rays, such as supernova remnants, and to discover new, fleeting sources of X rays.

● NASA and the Italian Space Agency cosponsor another mission, the Tethered Satellite System, also slated for a February launch. In this experiment, the shuttle will literally drop a line into Earth's ionosphere.

Some 270 km above Earth, the shuttle will deploy a small satellite connected by an electricity conducting umbilical cord to its mother ship. Thrusters on the satellite will fire, and after a little more than 6 hours the tether will stretch to its full length of 20 km. Generating high voltages and electric currents as it slices through Earth's ionosphere, the tether will plumb the space environment near Earth. Instruments in the satellite and in the shuttle's payload bay will measure the ionosphere's response to the moving tether. After several days, astronauts will reel in the tether and retrieve the satellite.

March

● Two U.S.-built devices, together known as the Cosmic Dust Experiment, ride a Russian craft to Mir, the Russian

space station. Cosmonauts will install the experiment, which uses aerogels and foams to collect cosmic dust particles. Later this year or early next, cosmonauts will remove the detectors for a return trip to Earth via space shuttle.

April

● In studying the chemistry of dense interstellar clouds, astronomers hope to gain a deeper understanding of how these gas clouds collapse to form stars. But Earth's atmosphere prevents ground-based telescopes from charting the distribution of certain atoms and molecules in the clouds. Carried aloft by a Pegasus rocket, NASA's Submillimeter Wave Astronomy Satellite (SWAS) is expected to record the distribution of water, molecular oxygen, carbon, and carbon monoxide in dense molecular clouds that lie within 3,000 light-years of Earth, including those within the constellations Orion, Taurus, Ophiuchi, and Perseus. SWAS will also examine gas-rich regions beyond the Milky Way, including our nearest neighbors, the Large and Small Magellanic Cloud galaxies.

May

● A prototype of an inflatable radio antenna is scheduled to take a one-way trip on the space shuttle in May. Deployed from the shuttle, the mylar antenna will inflate to 100 feet in length and 50 feet in diameter. As it rides for less than a day on a free-flying space platform known as Spartan, scientists will study its response to solar heating and pressure. Then astronauts will retrieve the reusable Spartan platform, leaving the prototype antenna to burn up in Earth's atmosphere. Among a variety of proposed applications, inflatable space-based radio antennas could scan the heavens to examine radiowave-emitting stars and galaxies, as well as to measure soil moisture on Earth's surface.

● The European Space Agency (ESA) and NASA plan to launch a mission to explore further the sun's influence on Earth. A group of four identical craft known as Cluster will fly in formation to study small-scale structures within Earth's magnetosphere—the region surrounding our planet that's dominated by the terrestrial rather than the solar magnetic field.

Engineers can adjust the spacing between the Cluster craft to measure the size and scale of the feature under study. Cluster joins another joint ESA-NASA mission called Soho, launched last December, and several other craft, including Polar, in the International Solar-Terrestrial Physics program. Collectively, these craft will help track how electromagnetic disturbances originating from the sun propagate through Earth's space environment. Comparison of measurements taken by the four Cluster craft should provide researchers with a three-dimensional map of the ionized gas, or plasma, in Earth's magnetosphere.

June

● If all goes according to plan, two missions will finally hitch a long-delayed ride on a Pegasus rocket. The Satélite de Aplicaciones Científicas-B (SAC-B), the first Argentinean spacecraft ever to fly, will use two spectrometers to study high- and low-energy X rays from solar flares. During the 3-year mission, a telescope on SAC-B will scan the heavens to survey the diffuse X-ray glow from hot gas in the Milky Way and from celestial sources far beyond. Yet another detector will search for the mysterious flashes of energy known as gamma-ray bursts. Like illumination from a cosmic flashbulb, these bursts emit a torrent of radiation and then vanish without a trace.

● The craft sharing a ride with SAC-B is designed to look for low-energy counterparts to gamma-ray bursts. The High-Energy Transient Experiment (HETE), an international project involving the United States, France, Italy, and Japan, carries a spectrometer to measure gamma-ray bursts ranging in energy from 6,000 to 1 million electronvolts. HETE carries a detector that can monitor the X-ray component of the bursts, as well as four ultraviolet cameras that will scan the sky whenever a burst appears.

Astronomers hope the cameras will record low-energy counterparts of the bursts. If successful, the cameras should help pinpoint the location of the bursts to a much higher accuracy than the Compton Gamma Ray Observatory, the main satellite now studying these flashes. On Earth, astronomers searching for visible-light counterparts of these ephemeral flashes will have the chance to receive immediate information from HETE.

July

● Shimmering over the polar regions, auroras have long fascinated skywatchers. In July, NASA plans to launch a low-flying craft that will take high-resolution snapshots of the charged particles and electric and magnetic fields associated with auroras. The Fast Auroral Snapshot Explorer (FAST) will record rapid variations in these fields and particles and attempt to reveal how electric and magnetic fields guide and accelerate charged particles, generating the auroral displays.

August

● When it comes to deciphering the complex interactions between solar activity and Earth, planetary scientists say there's no such thing as too many research craft. In August, the Russian Space Agency plans to get into the act, sending aloft the second component of its Interball Project, the Auroral Probe. This instrument and its subsatellite will make coordinated observations with the agency's Tail Probe, launched last August to explore the cometlike tail of Earth's magnetosphere. Together, the two probes will seek to reveal how the

MONTH	EVENT
January	Retrieval of Infrared Telescope in Space
	Polar
February	Near Earth Asteroid Rendezvous
	Satellite per Astronomia X
	Tethered Satellite System
March	Cosmic Dust Experiment
April	Submillimeter Wave Astronomy Satellite
May	Prototype radio antenna on Spartan
	Cluster
June	Satélite de Aplicaciones Científicas-B
	High Energy Transient Experiment
July	Fast Auroral Snapshot Explorer
August	Auroral Probe
September	First space-based component of interferometer
November	Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer
	Interstellar Medium Absorption Profile Spectrograph
	Mars Observer
December	Mars Pathfinder
	Mars 96

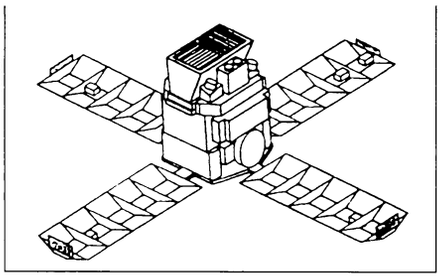
so-called magnetotail stores energy from the sun and later discharges it, in part by generating auroras. The Auroral Probe carries an ultraviolet camera and should complement observations taken by NASA's Polar spacecraft.

September

● The Japanese Space Agency plans to launch a craft that should become the first space-based component of the Very Long Baseline Interferometer, a global array of radio telescopes. This airborne radio antenna is intended to aid in producing sharp images of a variety of radio sources, including active galactic nuclei.

November

● On a shuttle flight, NASA expects to launch a U.S.-German mission that relies on a reusable satellite called Astro-SPAS. For the second time in 3 years, the satellite will carry three ultraviolet spectrometers to examine the atmosphere of hot stars and the composition of the interstellar medium. The spectrometers detect ultraviolet radiation at a key set of wavelengths—shorter than those detected by the Hubble Space Telescope but longer than those recorded by the Extreme Ultraviolet Explorer satellite. One set of instruments, known as ORFEUS (Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer), consists of two spectrometers and a 1-meter telescope designed to study emissions from ultraviolet-bright


NASA

The spacecraft to be used in the High Energy Transient Experiment.

stars at high spectral resolution. The other instrument, IMAPS (Interstellar Medium Absorption Profile Spectrograph), is a single spectrometer and telescope that can record the spectra of fainter stars but at lower spectral resolution. After separating from the shuttle, Astro-SPAS stays within 40 km of its mother ship for retrieval 6 to 7 days later.

● Three years ago, the Mars Observer spacecraft vanished just before entering orbit around the Red Planet. NASA hopes it will have better luck with the Mars Global Surveyor (MGS), scheduled for launch in November and arrival at Mars 10 months later. Seven of the surveyor's 11 instruments are replicas of those lost on the Observer. During the first 4 months after its arrival, MGS will use a combination of thruster firings and aerobraking (lowering its altitude by using atmospheric drag) to transform its elliptical orbit into a near-circular polar orbit 367 km above the Martian surface. In that configuration, the craft is slated to explore the Red Planet for 2 years, providing global maps of the Martian surface, mineral distribution, and climate. Following its mapping mission, the craft is expected to serve as a relay station, transmitting radio signals from other Martian missions.

December

● NASA plans to launch a second craft to the Red Planet. Mars Pathfinder is scheduled to land on Mars in July 1997. A small rover will explore the terrain surrounding the craft. In addition to testing new concepts in lander technology, the mission will study the structure of the Martian atmosphere, the geology of the surface, and the composition of Martian rock and soil. The primary mission lasts for about a month, but exploration could continue for an additional year.

● Another mission to Mars may also get off the ground in December. After a 2-year delay, the Russian Space Agency plans to launch a craft, now dubbed Mars 96, that includes four landers as well as an orbiter. A pair of cameras on the orbiter will provide astronomers with stereo views of the Martian surface, imaging features as small as 20 meters in length. Two of the craft's landers will use their pointed legs to penetrate several meters beneath the surface. All four landers will examine the composition of Martian rock and soil. □

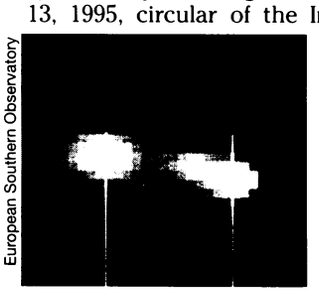
Astronomy

Breakup of a comet

Last September, something strange happened to a comet called Schwassmann-Wachmann 3. It became 1,000 times brighter. By October, skywatchers could even have detected it with the naked eye.

Simultaneously observing the icy body with two telescopes on the same Chilean mountaintop, astronomers have now found evidence of even more dramatic activity. The comet appears to have broken into three or four pieces. In infrared images taken with the European Southern Observatory's 3.6-meter telescope in La Silla, Hans U. Kaufl discerned three separate blobs. Five hundred meters away, Hermann Böhnhardt monitored the body in visible light with the observatory's New Technology Telescope. He also saw three blobs, two of which coincide with those seen in the infrared.

Astronomers Böhnhardt, of the Ludwig Maximilian University in Munich, and Kaufl, of the European Southern Observatory in nearby Garching, Germany, report their findings in a Dec. 13, 1995, circular of the International Astronomical Union. They made the observations in mid-December and estimate that the fragments were moving apart at the rate of 250 kilometers a day.


European Southern Observatory

Fragments of Comet Schwassmann-Wachmann 3.

On Dec. 27, using the Spacewatch telescope atop Kitt Peak near Tucson, James V. Scotti of the University of Arizona in Tucson confirmed that the comet had split. On Dec. 28 and 29, astronomers in Modria, Slovakia, observed the fragments.

If Schwassmann-Wachmann 3 broke apart as early as September, it would account for the comet's brighter appearance, notes Brian G. Marsden of the Smithsonian Astrophysical Observatory in Cambridge, Mass. Sunlight striking the exposed surfaces of a recently fragmented comet causes it to expel large amounts of gas and dust. The more dust a comet spews, the more light it reflects and the brighter it appears. Indeed, notes Marsden, if another comet, Shoemaker-Levy 9, hadn't fragmented into some 20 pieces, it might not have been visible when it smashed into Jupiter in July 1994 (SN: 12/17/94, p. 412).

Schwassmann-Wachmann 3, however, may not have shattered until after the September brightening, says Kaufl. Images taken in early December by other astronomers at La Silla do not show fragments; instead, they indicate an elongated nucleus. The images suggest that the nucleus of the comet split up no earlier than mid-November.

Kaufl speculates that although the breakup occurred after the comet brightened, the two events have a common explanation. Cracks and rifts on the icy nucleus may have widened in September, when the comet passed closest to the sun. The widening cracks would have not only released greater amounts of gas and dust, making the comet brighter, but also set the stage for later fragmentation, he suggests.

Regardless of when the fragmentation took place, it attests to the fragility of comets, notes Marsden. Over the years, astronomers have detected about 30 comets whose nuclei have split, leading some planetary scientists to theorize that each of these icy bodies consists of a loosely held assembly of house-sized snowballs (SN: 5/7/94, p. 298).